

Phase 1 Report for EPA-RARE Contract with The Ohio State University

Phase 1 Task 1. Literature Review

We reviewed the published literature and publicly accessible reports of corn seed treatment dust and its effects on honey bee colonies. This effort culminated in a short review of the topic that was published in the Ohio State Beekeepers Association quarterly newsletter (Appendix A) and a detailed timeline summarizing current knowledge and events (Appendix B)

Phase 1 Task 2. Database Construction

Existing US databases with reports of bee kills related to corn planting were found to be insufficient for any sort of analysis. Events in the US EPA Bee Kill database are summarized under 2012 in the summary timeline (Appendix B). Precise location information, in particular, was sorely lacking from most existing reports. To generate a more useful set of data we, in coordination with the Tri-County Beekeepers Association, surveyed beekeepers in Ohio attending the “TCBA Spring Workshop” held in Wooster, OH on March 1, 2014. A short paper survey (Appendix C) was included with the workshop materials and collected on-site. Submissions were also accepted through the online LimeSurvey system (<http://surveys.cfaes.ohio-state.edu/cfaes/index.php/survey/index/sid/633948/newtest/Y/lang/en>). Paper surveys were also distributed at state and local meetings and online surveys were accepted until August 31, 2014. This survey was granted exemption from Institutional Review Board review (Protocol #2014E0092) by The Ohio State University’s Office of Responsible Research Practices.

While several questions were asked, the principal questions of interest were “Where is your apiary located?” and “Did you notice any sudden increase in the number of dead bees in front of colonies in this apiary **in the months of April, May or June** in recent years?” Google Maps was used to determine the latitude and longitude of apiaries based on address or location descriptions provided by beekeepers. Each apiary site was mapped on the USDA-NASS Cropland Data Layer (Figure 1) for each year (<http://www.nass.usda.gov/research/Cropland/Release/index.htm>), and a 3km-radius foraging range was defined using QGIS (version 2.4). The composition of land use types within each apiary’s foraging area was then calculated using the LecoS plugin (version 1.9.3).

Of the 271 responses received, only 164 survey responses contained both an identifiable apiary site and a response to the question about the appearance of dead bees in front of colonies in this apiary in the springtime. All 164 surveys provided information for 2011 and before; 2012 and 2013. Since many surveys were completed prior to corn planting in 2014, the responses for 2014 were not analyzed. Raw landscape data and reports of dead bees for each year are available in Appendix D. Exact locations of apiaries are not reported in compliance with the IRB exempted experimental protocol.

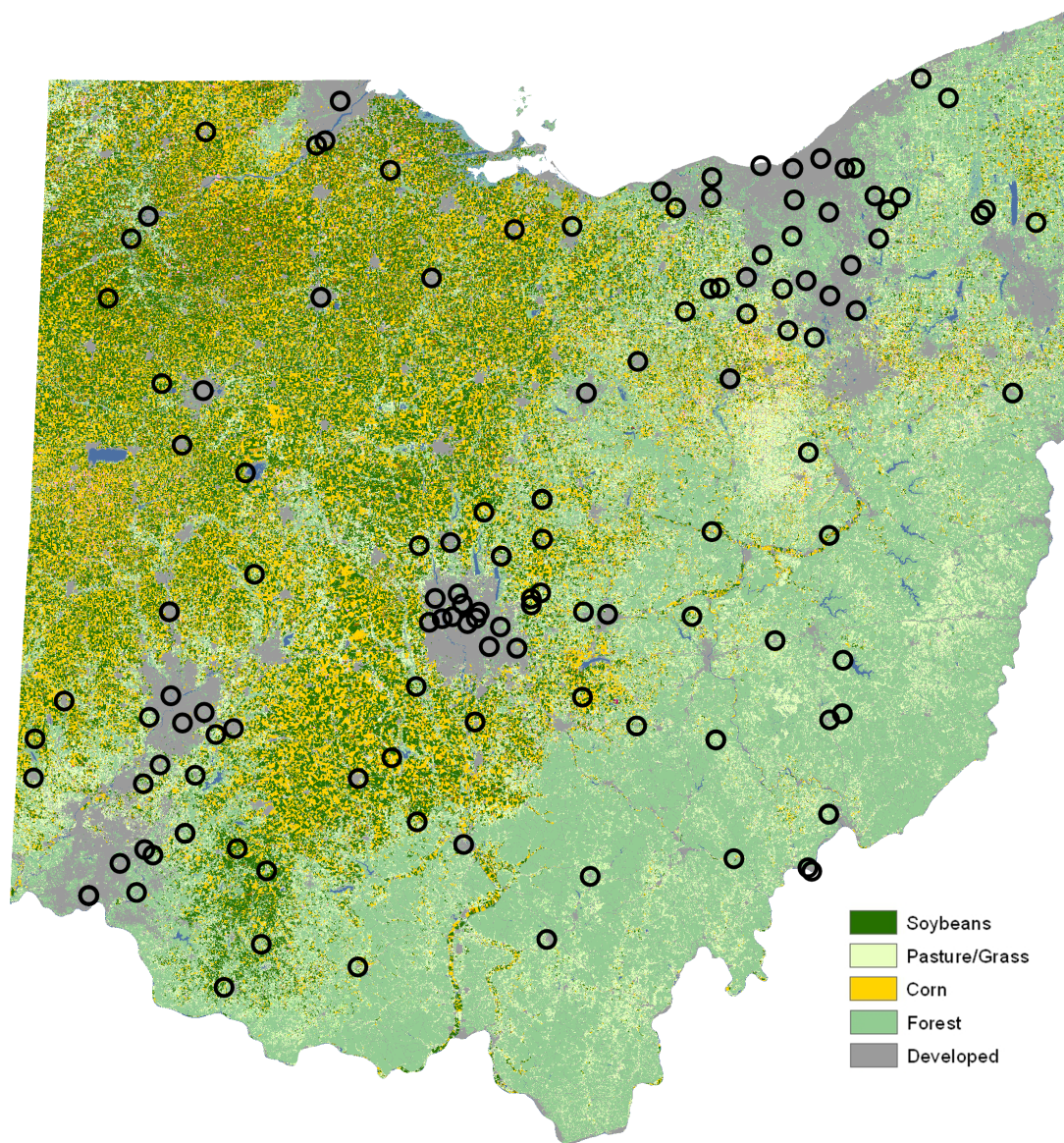


Figure 1. Foraging ranges (3km radius) for 164 apiaries managed by beekeepers participating in the survey.

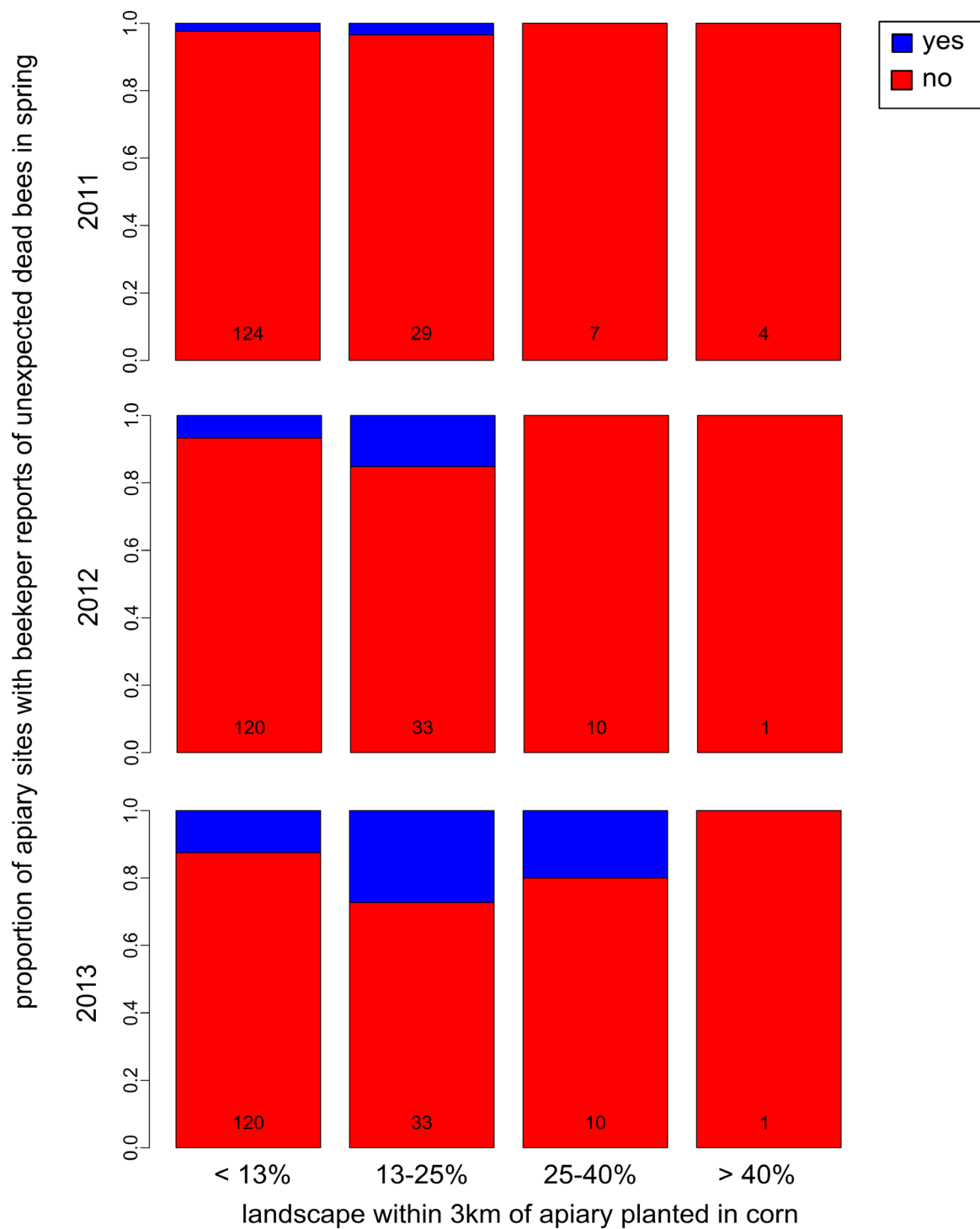


Figure 2. Ohio beekeeper survey responses to the question “Did you notice a sudden increase in the number of dead bees in front of colonies in this apiary in the months of April, May or June in any previous years?” categorized by the prevalence of corn within foraging range of bees at these apiary sites, as determined using the USDA-NASS Cropland Data Layer for each year. The number of respondents in each bin is indicated at the bottom of each bar.

Beekeepers responding to the survey represented a broad range of landscape types and most apiaries (84% in 2013) had corn planted within the 3km foraging range of bee colonies. However, relatively few beekeepers reported on apiaries maintained in areas of intensive corn cultivation. The average corn area for apiaries included in the survey was 6.7% (9.4% SD) for 2011, 7.2% (9.0%) for 2012 and 7.9% (10.2%) for 2013. There were several apiaries surrounded by corn fields -- the maximum area of corn planted around an apiary was 51.3% of bees foraging range. While this distribution of apiaries is not ideal for detecting problems in bee colonies associated with corn planting, it is representative of the apiaries in Ohio -- most of which are backyard apiaries operated by hobbyists.

Reports of observations of unexpected bee deaths in the springtime were not universal among the 164 Ohio beekeepers responding to the survey. Beekeepers reported just 4 events in 2011 and before, 13 in 2012 and 26 in 2013. Reports of dead bees increased over time ($p < 0.001$; Test of Equal Proportions).

It is certainly possible for beekeepers to observe dead bees for reasons that are unrelated to corn planting, but there does appear to be a relationship between the area planted in corn around an apiary and the appearance of dead bees in springtime. In 2012 and 2013 there was a positive relationship between the observation of dead bees and the area planted in corn around apiaries ($p < 0.05$, One-Way Wilcoxon Rank Sum Test). However, the handful of beekeepers with apiaries in the most corn-intensive sites appeared to be less likely to report the unexpected appearance of dead bees (Figure 2). Among the 26 beekeepers reporting the appearance of dead bees in 2012 and 2013 the mean area planted in corn within foraging distance of apiaries was 8.7% and 10.4%, respectively.

Discussion

It is difficult to interpret the results of this survey. However, there appears to be a clear indication that beekeepers are increasingly aware of bee mortality in the spring. While it is possible that increased reports are due to increased adoption of pneumatic planters, weather during planting or changes in weed management practices, all of which could affect bee exposure, it is more plausible that increased reports are a consequence of increased awareness among beekeepers of problems relating to seed treatment dust.

In our own experience collecting data for the Corn Dust Research Consortium project in 2013 (<http://www.pollinator.org/PDFs/CDRCfinalreport2013.pdf>), bees' exposure to corn seed treatment insecticides during planting is ubiquitous and commonly contaminates pollen at levels as high as 60 ppb. We believe that most of the apiaries with significant amounts of corn surrounding them experienced similar levels of exposure. Concomitant with corn planting and corn seed treatment dust exposure we also observed a visible increase in the number of dead bees caught in dead bee traps. However, without the use of dead bee traps and without a regular monitoring regime, this spike in dead bees could be easily missed. The effects of corn seed treatment dust exposure on bee colonies is relatively subtle, but appears to be consistent and could easily be detectable to anyone paying attention at the right time. As such, we expect reports of dead bees during corn planting to continue to increase -- not because the problem has fundamentally changed, but because beekeepers are more likely to be paying attention.

Appendix A: Literature Review

Published in the Ohio State Beekeepers Association Newsletter, April 2014.

<http://www.ohiostatebeekeepers.org/wp-content/pdf/newsletters/osba/OSBA%202nd%20Quarter%202014%20Newsletter.pdf>

Honey Bee Losses and Toxic Corn Seed Dust

Doug Sponsler, Chia Lin, and Reed Johnson
The Ohio State University Honey Bee Research Lab

The Story

In the late 1990s, beekeepers in the corn-growing region of northern Italy began noticing unusually large numbers of dead or disabled bees in early spring, during the period of local corn planting (1). Not long after that, similar complaints arose in neighboring France (2). Suspicions quickly became focused on the seed-treatment compound known as Gaucho® (Bayer CropScience), a product used widely in corn and containing the neonicotinoid insecticide *imidacloprid*. The evidence implicating Gaucho®, however, was inconclusive, and the reports of spring bee-kills remained anecdotal and poorly documented (3). The heated public discourse that followed attracted some international attention, but the pattern of spring bee kills associated with corn planting continued to be largely restricted to France and Italy, and the role of Gaucho® in those events was never confirmed.

This situation changed dramatically in 2008. In the preceding years, there had been two important developments. First, Gaucho® had been largely displaced by two novel seed-treatment compounds: Poncho® (Bayer CropScience) and Cruiser® (Syngenta). These new compounds contained the neonicotinoid insecticides clothianidin (Poncho®) and thiamethoxam (Cruiser®), close relatives of imidacloprid (Gaucho®) with slightly higher toxicity to honey bees. Second, the western corn rootworm, a devastating North American pest of corn that had invaded eastern Europe in the 1990s, was marching westward at an alarming rate and threatening severe damage to the European corn economy (4). Poncho® and Cruiser® offered a chance to stop the spread, so these compounds were widely used at their highest approved dosage during the 2008 corn planting season (5).

Once planting began, reports of bee-kills started coming in at an unprecedented rate. When all were tallied, damage had been reported for a total of nearly 20,000 hives belonging to over 900 beekeepers, located mainly in Germany and Italy, but also in France and Slovenia (1, 6-8). Unlike the earlier reports in Italy and France, these cases were generally well-documented and formally investigated by scientists representing government agencies, pesticide companies, and independent research institutions (5, 8, 9). The incidents occurred in tight synchrony with corn planting, and residues of clothianidin and thiamethoxam were detected in a large proportion of the dead bees that were sampled and analyzed. All sides agreed that seed-treatment insecticides had played a significant role in the 2008 honey bee losses.

Since the events of 2008, a variety of actions have been taken, both by government regulators and seed-treatment manufacturers, to mitigate the exposure of honey bees to seed-treatment insecticides during corn planting. Nevertheless, honey bee losses associated with corn planting have continued to be reported by beekeepers in Europe and, more recently, by

beekeepers in Canada and the United States (10-12). Among the latter are several beekeepers from right here in Ohio who saw losses during the 2012 corn planting season. Although the scale of these more recent incidents has been smaller than those of 2008, the pattern of losses and the circumstances surrounding them have been remarkably consistent, indicating that the now 15-year-old issue of honey bee mortality in connection with the planting of insecticide-treated corn remains unresolved.

Our Current Understanding

There is widespread agreement that the primary route by which honey bees are exposed to seed-treatment insecticides is foraging upon flowers that have become contaminated with insecticide-laden dust generated during pneumatic corn planting. During the planting process, seeds jostle against each other in the hopper, resulting in some abrasion of the pesticide coating. A portion of the resulting dust is then expelled through the exhaust port of the planter, which is typically directed up into the air. Depending on moisture and wind conditions, the insecticide laden dust can disperse some distance from the planter and settle on blooming plants outside the planted field. During the 2008 incident in Germany, exposure is thought to have been exacerbated by unusual spring weather that resulted in corn being planted during the bloom of canola, a favorite resource of honey bees that is often grown in close proximity to corn fields in Europe. Furthermore, analysis of seed samples revealed that many batches of treated seed planted in 2008 had been poorly manufactured such that an inordinate amount of the seed-treatment compound readily detached from the surface of the seed producing extremely high levels of dust (9).

Arguably, the biggest mystery surrounding the issue of honey bee mortality during corn planting is why incidents occur sometimes but not all the time. Virtually all the corn planted in the U.S. and much of the corn planted elsewhere is treated with neonicotinoid insecticides, and yet major bee-kill events, while widespread, have been far from universal. What are the circumstances that lead to a bee-kill event during corn planting? What, if anything, can be done to avoid these circumstances?

Those are the questions that our lab is trying to answer in an ongoing study here in Ohio. Data from the first year of our study have led us to two preliminary conclusions (for more details see: <http://www.pollinator.org/PDFs/CDRCfinalreport2013.pdf>):

1. Chemical analysis of pollen collected from our research colonies during the 2013 corn planting season revealed the pervasive presence of seed-treatment neonicotinoids, albeit at low concentrations. This is somewhat unsettling because there were ~~no~~ local reports, to our knowledge, of spring bee-kills in Ohio last year, indicating that bees may be exposed to background levels of neonicotinoids every spring, even when no acute effects are observed. Whether these background levels are high enough to cause sublethal effects is debatable, and our study was not designed to measure such effects.

2. When we separated our pollen by floral source prior to pesticide analysis, we found that the pollen bees collect during spring corn planting can be extremely variable in the concentration of neonicotinoids. This is a subtle but important insight. Bees do not forage on “average” pollen—they forage on some combination of contaminated and uncontaminated pollen. Thus, the low background levels we observed in the bulk pollen we analyzed represent a mixture that includes both highly contaminated and minimally contaminated pollen. Whether or not a bee-kill occurs on any given day may, therefore, be largely dependent on whether your hive

happens to forage heavily on a patch of flowers that received a large amount of contamination, such as dandelions growing downwind from a newly planted field.

What You Can Do

Based on our current understanding, there does not seem to be anything that you as a beekeeper can do to guarantee the safety of your hives this spring. The likelihood of having a major bee-kill is probably low, but it is dependent on factors outside your control, such as the foraging decisions of your bees, the availability of safe foraging habitat in your area, and the weather conditions at the time of corn planting.

What you can do, though, is make careful observations of your hives during the period of local corn planting. Be aware of planting activity in your area and if you notice large numbers of dead or dying bees during planting contact us immediately at one of the email addresses below.

Doug Sponsler
Graduate Research Associate
sponsler.18@osu.edu

Dr. Chia Lin
Postdoctoral Research Associate
lin.724@osu.edu

Dr. Reed Johnson
Assistant Professor of Entomology
johnson.5005@osu.edu

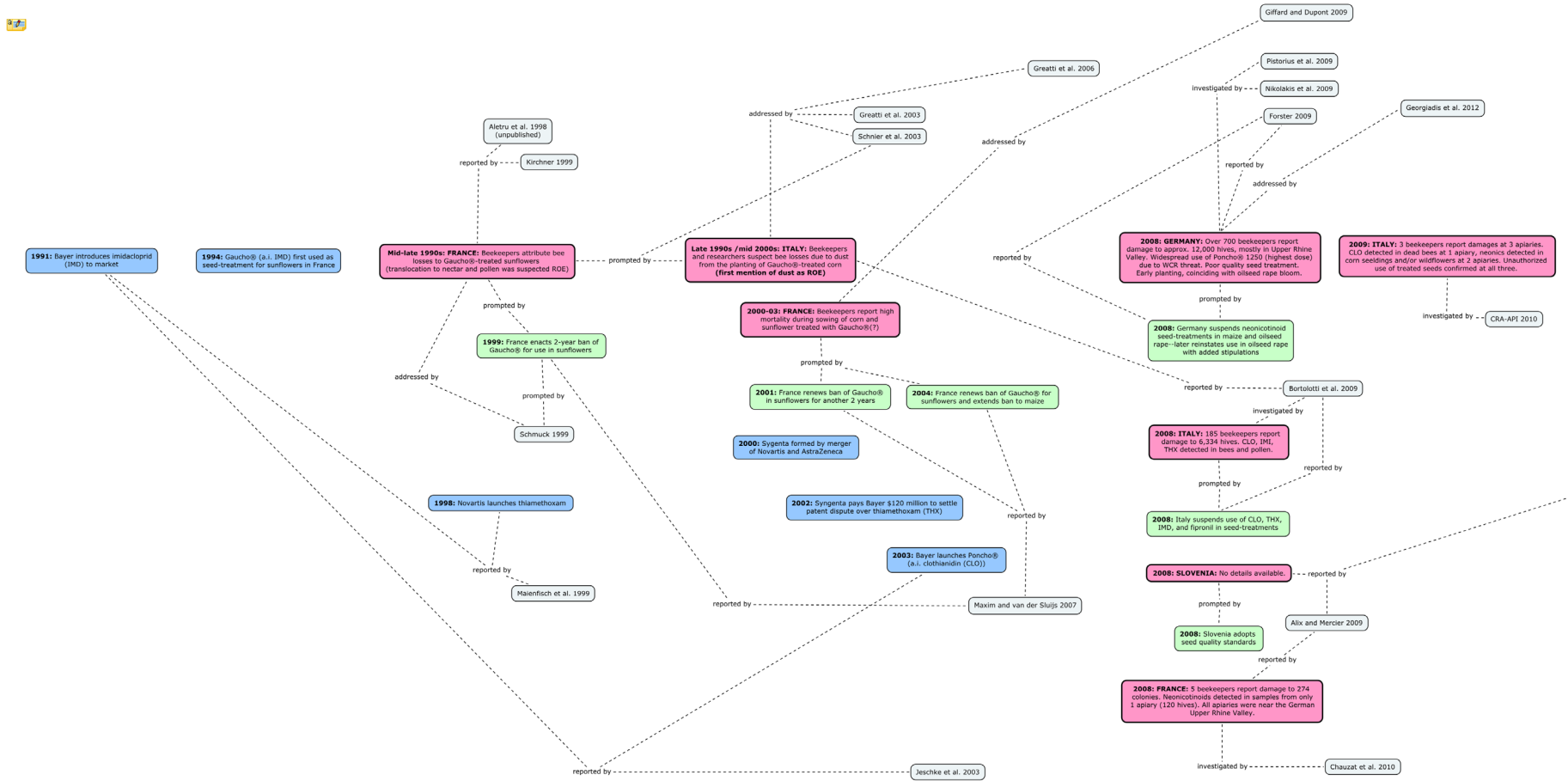
This work was funded by the Pollinator Partnership's 'Corn Dust Research Consortium', the United States Environmental Protections Agency's RARE program and state and federal support of The Ohio State University's Ohio Agricultural Research and Development Center (OARDC).

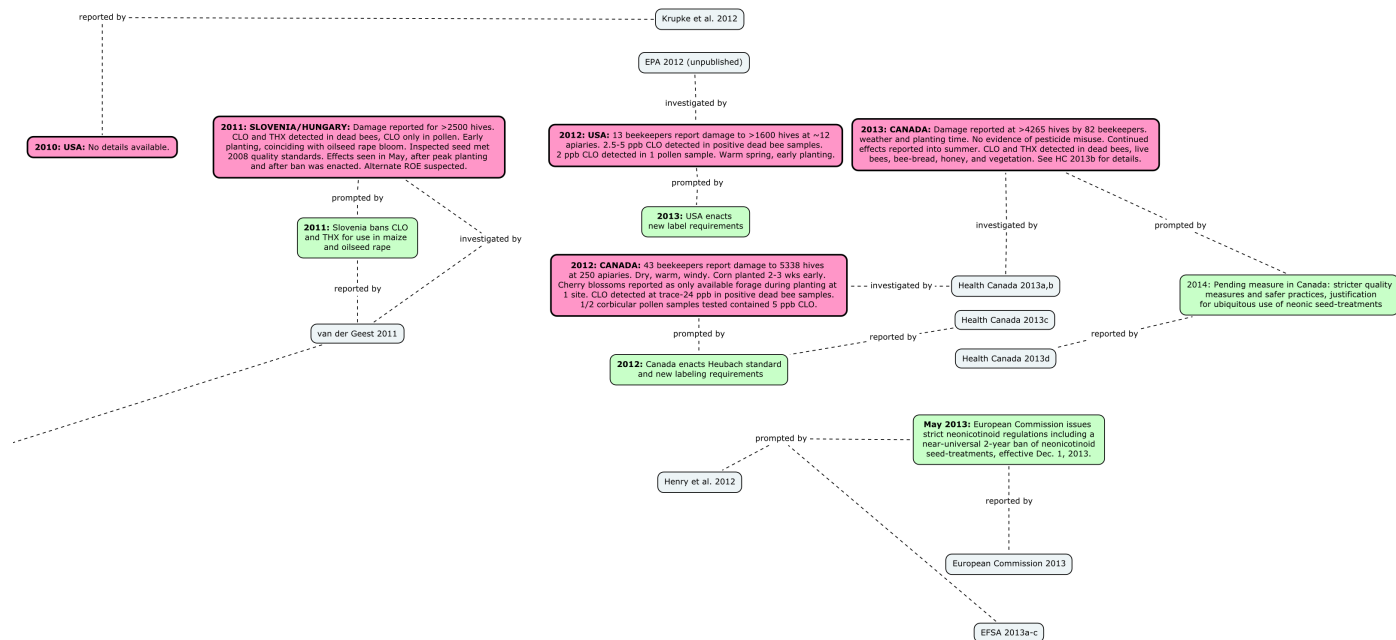
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Appendix B: Corn Seed Treatment Dust Chronological Flow Chart





I. Abbreviations

IMD = imidacloprid

CLO = clothianidin

THX = thiamethoxam

WCR = western corn rootworm

ROE = route of exposure

II. Linking terminology:

reported by = incident mentioned or qualitatively described, but no data presented

investigated by = incident described in detail, including the presentation of quantitative data

prompted by = publication or legislative action produced in direct response to indicated stimulus

addressed by = research conducted in response to incident but not analyzing the incident itself

Note: Linking terminology is not used strictly and terms are not mutually exclusive. For each relationship, the linking term deemed most appropriate was chosen.

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Appendix C: Survey of Ohio Beekeepers

Survey of Springtime Bee Health

Informed Consent

This is a study conducted by Dr. Reed Johnson, Assistant Professor of Entomology at the Ohio State University, to examine the success of honey bee colonies in the spring. Support for this survey came from a gift made by the Tri-County Beekeepers Association. The purpose of this study is to determine the effect of nearby crop fields on the appearance of dead bees in front of colonies in the springtime as well as the longer term success of bees kept near crop fields.

You are being asked to participate in this study because you are a beekeeper in Ohio and we value your beekeeping experience. To participate you will complete a brief survey, which will take 5 – 10 minutes. In the survey, you will be asked a few questions regarding the location of your apiary, survival of bee colonies in the apiary, and the type of crop fields, if present, in the nearby landscape. Your apiary does not need to be located near crop fields to participate. This survey is also online at <http://go.osu.edu/springbeesurvey> or through the QR code.



Your participation in this research survey is completely voluntary. You may skip any questions you feel uncomfortable answering or withdraw from the study at any time without any penalty. Any information you provide through this survey will be kept confidential and only the key personnel of Dr. Johnson's research team will have access to this information. Research summaries generated from this study will only be presented in a manner in which individual beekeepers and exact apiary locations are not identifiable. If you have any questions or concerns about the survey please contact Chia Lin (Lin.724@osu.edu, 614-596-5167) or Reed Johnson (Johnson.5005@osu.edu, 330-202-3523). For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251. We thank you for your participation!

By beginning the survey, you acknowledge that you have read this information and agree to participate in this research.

If you manage more than one apiary, **please complete ONE SURVEY PER APIARY.**

I. Background Information (Please select)

Are you 18 years of age or older? ☐ NO ☐ YES

Has this apiary been consistently registered with the Ohio Department of Agriculture for as long as you've maintained it?

☐ NO ☐ YES

If you answered "NO" to any of the above questions you are not eligible to participate in this survey. If you answered "YES" to both of the questions and would like to continue the survey, please turn to the next page.

II. Apiary Information

Where is the apiary located? Please provide one of the following: street address, latitude and longitude, or description of your apiary location so that it can be located on a map.

How many colonies are in the apiary? ☐ 1 – 3 ☐ 4 – 6 ☐ 7 – 9 ☐ 10 or more

Did you notice any sudden increase in the number of dead bees in front of colonies in this apiary **in the months of April, May or June** in recent years? (check all that apply)

☐ NO YES, ☐ in 2014 ☐ in 2013 ☐ in 2012 ☐ in 2011 or years prior

If you remember, please specify when (date, week, month, etc.) the sudden increase of dead bees occurred:

Did you experience an unexpected death of colonies in this apiary in recent years? (check all that apply)

☐ NO YES, ☐ in 2014 ☐ in 2013 ☐ in 2012 ☐ in 2011 or years prior

If you answered Yes, what time of year did the colonies die (check all that apply)

☐ January/February ☐ March/April ☐ May/June
☐ July/August ☐ September/October ☐ November/December

Is the apiary located within a ½ mile of any of these major agricultural fields? (check all that apply)

☐ No, there are no agricultural fields nearby

☐ Corn ☐ Soybean ☐ Hay/wheat ☐ Orchard ☐ Other: _____

If you are interested in receiving a summary of survey results please provide contact information:

Name: _____

Email: _____

Mailing address: _____

If you wish to submit this survey by mail, please send it to: Dr. Reed Johnson; The Ohio State University-OARDC; 1680 Madison Ave.; Wooster, OH 44691. Please submit by August 31, 2014.

Appendix D: Data for land use in apiary foraging range and observation of dead bees in spring for 2011 (and before), 2012 and 2013 in Ohio. All areas are in m². DO=Urban Openspace, DL=Low Density Urban, DM=Medium Density Urban, DH=High Density Urban, Deadbees=Report of dead bees in that year

id, Corn, Soybean, DO, DL, DM, DH, Deadbees, Year
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